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Impact of Conventional and Wind Energy Production on Human Health

Summary

The paper presents the impact of manufacturing electric energy on human health. The chosen method of eclectic energy production, on the one hand, is a factor facilitating the improvement of the standard of living; on the other hand, however, it may have a significantly adverse effect on the quality of life.

The purpose of the article is to present the impact of energy production from conventional sources and wind turbines on human health and related health costs.

ExternE methodology was used to present the health impact of manufacturing energy from conventional sources and to assess the health costs of such a solution. The production of energy from conventional sources poses great danger to human health, thus, one of the alternative ways of providing energy might be switching to wind power – clean, renewable and, most importantly, not causing irreversible damage to the environment and human health.

The expert analyses and research used in characterizing the impact of wind power plants on human health unanimously pointed out that, so far, no adverse effect of this method of producing energy on human health has been stated.

Keywords: commercial power industry, wind energy, health.

Streszczenie

W artykule przedstawiono, jaki wpływ na zdrowie ludzi ma wybór sposobu produkcji energii elektrycznej, która z jednej strony jest czynnikiem wpływającym na poprawę poziomu życia, z drugiej zaś powoduje znaczny spadek jego jakości.

Celem autorki jest przedstawienie wpływu produkcji energii ze źródeł konwencjonalnych i turbin wiatrowych na zdrowie człowieka i związane z nim koszty zdrowotne. Prezentując wpływ produkcji energii ze źródeł konwencjonalnych na zdrowie, zastosowano metodologię ExternE, by ustalić koszty zdrowotne takiego rozwiązania.

Produkcja energii ze źródeł konwencjonalnych stwarza duże zagrożenie dla zdrowia ludzi, stąd jednym z alternatywnych sposobów dostarczania energii może być przejście

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na energetykę wiatrową – czystą, odnawialną – i co najważniejsze – niepowodującą nieodwracalnych szkód dla środowiska i zdrowia ludzi.

Charakteryzując oddziaływanie elektrowni wiatrowych na zdrowie ludzi, wykorzystano analizy i badania ekspertów, którzy wskazali jednoznacznie, że dotychczas nie stwierdzono negatywnego wpływu tego sposobu wytwarzania energii na zdrowie ludzi.

Słowa kluczowe: energetyka zawodowa, energetyka wiatrowa, zdrowie.

JEL: O13,I15

Introduction

Poland has the most polluted air of all EU Member States. The WHO report of 2015 entitled "Economic cost of the health impact of air pollution in Europe" indicates that in 2010 air pollution in Poland contributed to death of 48,544 Poles, which in turn generated costs in the amount of USD 101.826 billion. It estimates that air pollution by particulate matter PM2.5 is responsible for nearly 0.5 million premature deaths in Europe (more than 400,000 in 28 EU countries), including nearly 80% of deaths from respiratory diseases and lung cancer (EEA, 2014; Juda-Rezler et al., 2016). Another WHO report (WHO, 2016) states that as many as 33 out of 50 most polluted EU towns and cities are located in Poland.

This disturbing data made the battle for clean air a European and global priority. Representatives of many countries meet during the so-called climate summits to develop joint solutions. The topic of producing energy from renewable sources, which have to replace the conventional ones in order to provide people with proper quality of life and safety, is widely discussed during these talks.

According to *Gospodarka Paliwami i Energią*, 500 kg of coal must be used in order to produce 1 MWh of electric energy, resulting in the following emissions to the atmosphere: (Soliński et al., 2010):

- 850 kg CO_2 (carbon dioxide),
- 10 kg SO_2 (sulphur dioxide),
- 11 kg CO (carbon oxide),
- 4 kg NOx (nitrogen oxide).

The above comparison leaves no doubt that the production of energy from conventional sources poses great danger to human health.

1. The Effects of Pollution Resulting From the Production of Conventional Energy

The environmental impact of the energy sector includes pollution of atmospheric air, soil, surface waters and the global climate change, which have a number of negative economic and health effects. The main harmful factors are the emissions of gaseous pollutants such as: CO_2, SO_2, NOx and the particulate matter from the fossil fuel combustion process. The most common diseases associated with air pollution are respiratory diseases; however, the air quality may affect human health much more than it may seem. Numerous scientific studies confirm the influence of air pollution on the increased occurrence of respiratory diseases, but also cardiovascular diseases, chronic obstructive pulmonary disease (COPD), increased risk of developing various types of cancer – not only respiratory-related – as well as on the nervous system and increased mortality, especially of people in the exposure group.

In the process of energy production, a power plant introduces pollutants having adverse side effects (cf. Table 1), which generate further economic effects (cf. Table 2).

Table 1. Harmful Agents Related to Electric Energy Production and Their Effects Included in ExternE Project

Pollution	Effects
Sulphur dioxide – SO_2 Directly emitted in the process of fuel combustion, it forms sulphuric acid, sulphate aerosols and acid molecules together with NOx in reactions in the atmosphere.	Health effects indirectly induced by sulphate aerosols (see: fine dust). Reduction in agricultural productivity. Erosion, loss of colour, etc. of construction materials (zinc, galvanised steel, limestone, paint, etc.). Acidification of soil and water.
Nitrogen oxides – NOx Family of chemical compounds, including nitrogen oxides and dioxides. Directly emitted in the process of combustion, they form nitrogen acids in the atmosphere, nitrate aerosols and ozone smog on sunny days.	Health effects indirectly induced by nitrate aerosols (see: fine dust). Acidification of soil and water and eutrophication of surface waters.
Fine dust – PM2.5, PM10 (diameter < 2.5 (10) mm) Primary – emitted directly in the process of hydrocarbon fuel combustion – and secondary – aerosols of nitrates and sulphates	Increased mortality (sudden and premature deaths due to chronic exposure to inhalation of contaminants). Increased morbidity (respiratory and cardiovascular diseases, asthma attacks, bronchitis, chronic cough,

Table 1. cont.

Pollution	Effects
formed in the atmosphere as a result of chemical reactions of SO_2 and NOx.	lung capacity reduction, days of limited activity, etc.).
Non-methane volatile organic compounds – NMVOC Huge number of organic compounds playing the leading role in the process of forming ozone (photochemical) smog.	Reducing life expectancy due to short and long-term exposure. Risk of cancer (non-fatal), osteoporosis, kidney dysfunction, disorders of the nervous system.
Ozone – O3 Formed in the atmosphere in reactions between NOx and other pollutants, including NMVOC, in the presence of sunlight	Increased mortality and morbidity (respiratory system, irritated eyes, days of limited activity, etc.). Reduction in agricultural productivity (crops, potatoes, rice, sunflower seeds...)
Heavy metals – Hg, As, Cd, Ni, Pb … Natural components of coal, emitted in the combustion process.	Toxicity and carcinogenicity.
Radioactive elements Risk of radiation occurs throughout the nuclear fuel cycle chain as well as in the migration of radioactive elements contained in coal in the process of its use.	Neoplasms (treatable and incurable), hereditary damage.
Greenhouse gases – CO_2, N_2O, CH4, … Direct product of hydrocarbon fuel combustion.	Global impact on human mortality and morbidity, agricultural crops, ecosystems, energy demand, economy, etc., as a result of changes in temperature and increases in sea and ocean levels.

Source: ExternE 1995, as cited in Radović (n.d., p. 3).

1.1. Health Costs of Producing Energy From Conventional Sources

Calculation of economic effects – including health costs of producing energy from conventional sources – in monetary terms is subject to controversy. The method used most commonly for electricity systems is the estimate of the amount of external costs. Currently, the most developed methodology for classifying external costs is considered to be the "impact pathway" approach, presented in the European Commission's ExternE proposal (European Commission, 2003, p. 7), followed by NewExt (New Elements for the Assessment of External Costs from Energy Technologies), ExterneE-Pol (Externalities of Energy: Extension of Accounting Framework

and Policy Applications), NEEDS (New Energy Externalities Developments for Sustainability) and CASES (Costs Assessment of Sustainable Energy Systems).

For the purpose of the paper, only the health costs which are also included in the external cost methodology have been calculated. ExternE methodology estimates the effects of increased human mortality. They are defined as premature deaths, formulated as cumulated reduction of the population life expectancy (YOLL – years of life lost). YOLL expressed in the corresponding curves (E-R exposure result) take into account the age distribution and life expectancy of the survey population (Ralb & Spadaro, 2000, pp. 601–627). Monetary valuation of health and environmental damage is the issue of subjective evaluation, as there is no market value for e.g. health damage. The costs of damage are expressed by the estimate of the "willingness to pay" (WTP) for the reduction of health risk or "willingness to accept" (WTA) payments for increased risk. The main parameter to assess the costs of increased mortality is the "value of statistical life" (VSL). It constitutes the basis to assess the value of the lost (statistical) year of life. The value of this parameter recommended in ExternE for Europe and the USA falls within the range of EUR 1–5 million.

The VOLY (value of life year) parameter is calculated based on the value of lost life parameter VSL estimated at ca. EUR 1 million. This value consists in estimating the changes in life expectancy associated with a reduction in the risk of death from 5 to 1 thousand people in the next 10 years. The indicator thus calculated using a 3% discount is EUR 40,000 for long-term exposure and EUR 60,000 for short-term exposure for all EU Member States. This provides a picture of people's willingness to annually spend such an amount of money that would enable them to prolong their lives for the period of 10 years. The most significant research conducted in terms of valuation of the external costs of energy is included in the ExternE project (European Commission), a study conducted by the US Department of Energy (External Costs of Cycles) and a study for New York (Rowe et al., 1995).

Table 2 shows that the health costs caused by the energy sector from 2010 to 2013 decreased significantly (from EUR 5.08 billion in 2010 to EUR 3.14 billion in 2013, i.e. by 38.2%). In 2014 they increased by EUR 7.59 billion compared with 2013, but decreased again in 2015 compared with 2014 (by EUR 122 billion, i.e. 3.2%). Decreasing costs were the effect of the growing share of energy from renewable sources (RES) in total energy production.

Table 2. Health Costs Caused by Energy Sector in 2010–2015 (million EUR/Mg)

	Particulate matter $\sum PM_{2.5\text{-}10}, PM_{2.5}$	NOx	SO_2	CO_2	Total
Unit external cost EUR/Mg	17.0	5.76	7.77	0.02	30.55
2010					
Emission, thousand Mg	39.6	272	474	189315	
Health costs	660	1144	3278	–	5,082
2011					
Emission, thousand Mg	18	228	357	173822	
Health costs	300	959	2469	–	3,728
2012					
Emission, thousand Mg	17	212	319	170057	
Health costs	283	891	2206	–	3,380
2013					
Emission, thousand Mg	17	203	290	171137	
Health costs	283	854	2005	–	3,142
2014					
Emission, thousand Mg	28	213	367	163029	
Health costs	467	896	2538	–	3,901
2015					
Emission, thousand Mg	28	202	356	164639	
Health costs	467	850	2462	–	3,779
Total health costs					22,994

Source: own calculations based on the data from NEEDS and GUS, (-) means "no data available".

2. Wind Power Engineering and Its Impact on Human Health

The development of wind power engineering in Poland results from the assumptions of Polish state energy policy, but also from global tendencies. The development of renewable energy sources, including the ones using wind power, seems necessary in Poland, due to the need to fulfil the Polish ecological obligations, specifically in terms of adjusting to the requirements of EU directives (Directive 2009/28/EC).

The purpose of a wind power plant is to generate electricity through the use of wind kinetic energy. Power plants use a self-renewable source; hence,

they are considered facilities producing the so-called "green", ecological energy. It is believed, however not scientifically proven so far, that they may adversely affect human health by emitting noise, infrasounds (noise below the threshold of audibility, i.e. in the range of 1–20 Hz (according to ISO 7196) and electromagnetic radiation.[1].

Wind power plants usually generate an infrasound intensity of about 60 dB (200 m from the tower; the further away; the lower the intensity), whereas regular wind produces as much as 110 dB at the infrasound level, while a car generates even 120 dB. Scientific research indicates that infrasounds may result in permanent, harmful changes to the organism only when the level of acoustic pressure exceeds the value of 140 dB (some sources 120 dB). The main aim of the Act: The "Environmental Protection Law" is a presentation of issues related to, among others, noise emission understood as sounds with frequencies ranging from 16 Hz to 16000 Hz generated during the operation of installations, technical equipment, means of transport and construction objects. The impact of noise on the environment means the impact on human health. Undesirable or unwanted vibrations are usually referred to as noise. The impact of noise on human health may be divided into: impact on the human nervous system (i.e. the effect of "hearing sounds"), when there are many of them, they are too loud, we talk about noise; non-auditory impact – the effect of the energy of vibrations on human organs or tissues (Simiński, 2008). The report prepared for the EU by the Institute for Environment and Health, Leicester University, specifies noise as currently one of the most serious environmental factors with negative impact on the "well-being" of people in Europe. Generally speaking, sounds up to 35 dB are not detrimental to health, only their increase to 70 dB causes fatigue to the nervous system. Sounds have negative impact on health at above 70 dB, while the level above 90 dB can be described as dangerous (Simiński, 2008). The noise generated by the rotating blades of a windmill will be heard only in the immediate vicinity of the power plant. Modern technologies allow for reducing the noise level to a minimum.

Infrasound may be a nuisance causing excessive fatigue, discomfort, drowsiness, impaired balance and psychomotoric functions and impaired physiological functions. An event of the resonance of structures and internal organs of the body may occur. All these phenomena are perceived and described by the individuals in a subjective way and depend on the

[1] The Regulation of the Minister of the Environment of 14 June 2007 on permissible noise levels in the environment (Journal of Laws [Dz.U.] 2007, No. 120, item 826) defines the maximum permissible noise levels for various buildings, areas or times of day.

individual sensitivity. It should be emphasised that every person who works and pursues active lifestyle is exposed to infrasounds in their environment, regardless of the nature of their work and place of residence.

The American Wind Energy Association and the Canadian Wind Energy Association established an international multidisciplinary scientific panel in 2009, *comprised of independent experts in acoustics, audiology, medicine and public health.* The objective of the panel was to review of the current literature on the potential detrimental effect on human health of the exposure to wind turbine sound and prepare a complex and widely available informative document on the subject. The outcome of the panel's works is the report published in 2009, entitled "Wind Turbine Sound and Health Effects. An Expert Panel Review" (Colby et al., 2009). The authors have concluded the following:

1. Noise emitted by wind turbines does not pose a risk of hearing deterioration or loss. Such risk may occur only when the sound pressure level exceeds 85 dB. Noise emitted by wind turbines does not exceed this sound pressure limit.
2. Experiments have shown that infrasounds emitted at a level of 40 to 120 dB do not have adverse health effects.
3. Human body vibrations caused by a sound of resonance frequency (i.e. a frequency which causes an increase in the amplitude of vibrations of the system on which a given sound has impact) only occur in the case of very loud sounds (exceeding 100dB). Considering the level of noise emitted by wind turbines, such a phenomenon is not involved in their case.
4. In many cases, the negative impact of wind turbines on human health and wellbeing is a result of the so-called nocebo effect (as opposed to the placebo effect). Anxiety, depression, insomnia, headaches, nausea and difficulty concentrating are common symptoms frequent in every person and there is no evidence that the frequency of their occurrence increases significantly among people living in the vicinity of wind farms (causing the so-called "wind turbine syndrome"). The nocebo effect associates the occurrence of such symptoms not with a potential source of such discomfort (in this case, a wind farm), but with a negative attitude towards it and lack of acceptance of its presence.
5. The "wind turbine syndrome" is based on the improper interpretation of physiological data of the persons potentially suffering from this disease. Its identified symptoms actually comprise the so-called annoyance syndrome, which can be caused by many factors and cannot be linked, only and exclusively, to the presence of wind turbines.

6. There is no reliable research or evidence that wind turbines cause the so-called Vibroacoustic Disease (VAD), a disease resulting in disorders in the whole human body. Animal studies have shown that the risk of developing the disease occurs in the case of a continuous – a minimum of 13 weeks – exposure to low frequency sounds emitted at a level of ca. 100 dB, namely ca. 50–60 dB higher than that emitted by wind turbines.

The main sources of electromagnetic field, directly related to a wind power plant, are the wind turbine generator and the output transformer. These devices are mounted inside the nacelle, i.e. at a significant height, hence their impact on the level of the electromagnetic field measured at ground level is low, if measurable at all. Moreover, the devices are placed inside the nacelle and enclosed in a space surrounded by a metal conductor with screening properties, which results in the effective impact of a wind turbine on the shape of the electromagnetic climate of the environment being equal to zero (www.archiwalnybip.warmia.mazury.pl). Moreover, as proven by epidemiological studies to date, no direct impact of the electromagnetic field generated by high-voltage power lines and substations on the health and lives of people exposed to the electromagnetic field emitted by everyday appliances on a daily basis (see: Table 3) has been identified so far.

Table 3. Typical PEM Values for the Selected Sources of Radiation

Type of device	Magnetic field intensity (uT) at a distance from the device		
	2.5 cm	**30 cm**	**1 m**
Hairdryer	6–2000	0.01–7	0.01–0.03
Electric shaver	15–1500	0.08–9	0.01–0.03
Vacuum cleaner	200–800	2–20	0.13–2
Fluorescent lamp	40–400	0.5–2	0.02–0.25
Portable radio broadcast receiver	16–56	1	< 0.01
Electric oven	1–50	0.15–0.5	0.01–0.04
Washing machine	0.8–50	0.15–3	0.01–0.15
Iron	8–30	0.12–0.3	0.01–0.03
Dishwasher	3.5–30	0.6–3	0.07–0.3
Refrigerator	0.5–1.7	0.01–2	< 0.01
Computer	0.5–30	< 0.01	–

Source: Bieńkowski and Zubrzak (2011).

The permissible values of physical parameters of electromagnetic fields have been defined in the Regulation of the Minister of the Environment regarding the permissible levels of electromagnetic fields in the environment and methods of checking compliance with these levels from October 30, 2003 [Journal of Laws [Dz.U.] no. 192, item 1883]. Compared with the global regulations, in terms of the restrictions regarding electromagnetic field emissions and radiation, the Polish regulations are considered one of the most restrictive.

Conclusion

As the emission-free technology, renewable energy reduces CO_2 emission, thus significantly facilitating the improvement in the quality of air cleanliness (WWF report, 2014) and hence improving the climate quality, making it one of the main tools for implementation of the provisions of the 1992 United Nations Framework Convention on Climate Change and the Kyoto Protocol. Replacing coal energy with wind energy allows for avoiding the emission of pollutants.

In times of crisis, which the world is heading towards at an ever faster pace, we ask ourselves: should we continue economic growth or give it up in favor of economical and rational management and healthier living? The rational management of natural resources is an important element of economic growth, which is supposed to bring economic, social and environmental effects. The development of renewable energy sources should be a priority objective for all countries, and environmental protection and economy should be compatible with sustainable development. Considering future generations, as the French writer and poet Antoine de Saint-Exupéry said, “We do not inherit the Earth from our parents, we borrow it from our children”, we are obliged to take care of this good today. According to research, wind energy is becoming essential for the proper functioning of the economy and mainly for healthy living and respect for the environment.

Effective action to curb climate change depends on well-defined and efficient governance systems. An increasing number of European countries have been adopting national frameworks to organize their climate actions, often in the form of climate laws.

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